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Claim 20 was objected to as depending upon itself. The Applicant has amended claim 20 to depend from base claim 1. Accordingly, withdrawal of the rejection of claim 20 is respectfully requested.

Claims 1-8, 10, 11, 14, 16, 17-26 and 50-52 stand rejected under 35 U.S.C. §102(b) as being anticipated by United States Patent No. 5,979,534 to Shibata et al. Additionally, claims 9, 12, 13, 15 and 55-57 stand rejected under 35 U.S.C. §103(a) as being unpatentable in view of United States Patent No. 5,979,534 to Shibata et al. The Applicant respectfully traverses these rejections for at least the following reasons.

Independent claim 1 is directed to a method of producing a semi-solid material without stirring, and has been amended to recite the steps of heating a metal alloy to form a metallic melt, regulating the transfer of an amount of the metallic melt into the vessel, and crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate less than 0.5 degrees Celsius per second to form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix. As an initial matter, the Applicant has amended independent claim 1 to improve its form by combining the steps of transferring and regulating. The Applicant submits that such amendment does not constitute the addition of new subject matter. Additionally, the Applicant has amended independent claim 1 to specifically recite that the controlled rate of cooling of the metallic melt is less than 0.5 degrees Celsius per second.

Notably, the '534 patent reference fails to teach or even suggest the cooling of a metallic melt at a controlled rate less than 0.5 degrees Celsius per second. To the contrary,

the '534 patent reference discloses a cooling rate that is greater than 0.5 degrees Celsius per second to produce a semi-solid material having a predetermined microstructure. Specifically, the '534 patent specification generally discloses that "[i]t is preferable to set this cooling speed [of the molten metal] below 10 K/s" (col. 4, ll. 39-40), and specifically discloses that "it is preferable to fix the cooling speed of the casting sleeve 2 from 0.5 to 8 K/s, and preferably 1 to 4 K/s." (Col. 7, ll. 3-4). There is no indication or suggestion whatsoever that the cooling rate of the molten metal is controlled at a rate that is less than 0.5 degrees Celsius per second. Additionally, the Applicant notes that the disclosed cooling rates of 0.5 to 8 K/s and 1 to 4 K/s are for the casting sleeve 2, and are not necessarily reflective of the cooling rate of the molten metal contained within the casting sleeve. Indeed, the cooling rate of the molten metal will almost certainly be higher than that of the casting sleeve 2 when taking into consideration the effects of ambient heat loss through the charge opening in the casting sleeve as well as the heat absorbed from the molten metal via the walls of the casting sleeve and the plunger 3 during the initial charging of the casting sleeve 2. As a result, the cooling rate of the molten metal is almost certain to be significantly higher than the disclosed cooling rate of the surrounding casting sleeve 2.

Additionally, the Applicant submits that providing a cooling rate of the metallic melt that is less than 0.5 degrees Celsius per second would not be an obvious design choice over the method and apparatus disclosed in the '534 patent reference. There are two primary factors that contribute to achieving a cooling rate of the metallic melt that is less than 0.5 degrees Celsius per second. One factor is the inclusion of a temperature-controlled vessel that

is capable of providing the relatively high degree of accuracy and precision necessary to achieve the recited cooling rate. With regard to the present invention, a temperature-controlled vessel is disclosed which includes a plurality of heat transfer zones that are adapted to independently control the temperature of the metallic melt disposed adjacent thereto, including regulation of the temperature of the metallic melt adjacent either or both of the end walls of the vessel. On the other hand, the casting sleeve 2 disclosed in the '534 patent reference merely includes cooling lines that run axially along the side wall of the casting sleeve 2. However, there is no indication of providing a plurality of heat transfer zones, nor for regulating the temperature of the metallic melt adjacent either end of the casting sleeve 2.

Additionally, another factor that contributes to achieving a cooling rate of the metallic melt that is less than 0.5 degrees Celsius per second is providing relatively tight regulation over the transfer of the metallic melt into the vessel. Such regulation includes, for example, preheating the vessel to a temperature that is sufficient to avoid a rapid drop in temperature of the metallic melt during initial charging of the vessel. In one embodiment of the present invention, the vessel is disclosed as being preheated to a temperature that is at or near the initial temperature of the metallic melt. However, the '534 patent reference fails to disclose preheating of the casting sleeve 2 to such a high temperature. Moreover, other factors provided by the present invention contribute to achieving a cooling rate of metallic melt that is less than 0.5 degrees Celsius per second, including regulation of the transfer of a select amount of the metallic melt into the vessel at a selected transfer temperature and at a selected transfer rate. While the '534 patent reference appears to provide some degree of control over

the temperature of the molten metal prior to being poured into the casting sleeve 2, there is no teaching or suggestion regarding regulation of the amount or rate of transfer of molten metal into the casting sleeve 2.

For at least the above-discussed reasons, the Applicant submits that the cooling rate recited in amended independent claim 1 is neither taught nor suggested by the '534 patent reference. Accordingly, the Applicant respectfully requests withdrawal of the rejection of independent claim 1.

Dependent claims 5-9 and 11-26 depend either directly or indirectly from independent claim 1 and are patentable for at least the reasons supporting the patentability of base claim 1. Additionally, further reasons support the patentability of the claims depending from base claim 1. For example, claims 8 and 9 recite that the regulating includes transferring the metallic melt into the vessel at a selected vessel temperature that is between about 606 degrees Celsius and about 610 degrees Celsius. However, the '534 patent reference neither discloses nor suggests that the temperature of the casting sleeve 2 is anywhere near the recited temperature range prior to the introduction of the molten metal therein. The Applicant notes that the passage cited on page 4 of the Office Action (col. 6, ll. 65-67 through col. 7, ll. 1-5) refers to the temperature of the molten metal after being introduced into the casting sleeve 2, and does not in any way refer to the temperature of the casting sleeve prior to the introduction of the molten metal therein.

Additionally, claim 11 recites that the regulating further includes transferring the metallic melt into the vessel at a selected rate of transfer, with claims 12 and 13 reciting

specific ranges for the selected rate of transfer. However, the '534 patent reference neither discloses nor suggests any regulation or control whatsoever over the rate of transfer of the molten metal into the casting sleeve 2. Moreover, claim 14 recites that the regulating further includes transferring a select amount of the metallic melt into the vessel, with claim 15 reciting a specific range for the select amount of metallic melt transferred into the vessel. However, the '534 patent reference fails to teach or suggest that regulation of the amount of molten metal transferred into the casting sleeve 2 is of any importance whatsoever. The Applicants also submit that regulation of the amount of metallic melt transferred into the vessel is not a mere matter of design choice. To the contrary, the selected amount of metallic melt that is transferred into the vessel can have a significant effect on controlling the cooling rate of the metallic melt. For example, transferring small quantities of metallic melt into the vessel can result in rapid cooling of the metallic melt, while transferring large quantities of metallic melt into the vessel can result in non-uniform cooling rates that tend to produce a non-homogenous semi-solid microstructure.

Claim 16 recites that the regulating includes controlling a differential between the temperature of the metallic melt during the heating and the temperature of the metallic melt during the transferring, and claim 17 further recites that the regulating includes controlling a drop in temperature of the metallic melt during the transferring of the metallic melt into the vessel. While the '534 patent reference appears to disclose a preferred heating temperature range of the molten metal and a preferred temperature range of the molten metal prior to being charged into the casting sleeve 2, there is no indication or suggestion regarding

providing control over the temperature differential between the molten metal during the heating stage and the transferring stage. Likewise, the '534 patent reference fails to disclose or suggest providing control over the temperature drop of the molten metal during its transfer into the casting sleeve 2. The Applicant submits that each of these steps has an effect on producing a semi-solid material having a predetermined microstructure.

Claim 2 has been rewritten in independent form and is directed to a method of producing a semi-solid material without stirring, and now recites the steps of heating a metal alloy to form a metallic melt, regulating the transfer of an amount of the metallic melt into a temperature-controlled vessel, and crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate within a range of about 0.01 degrees Celsius per second to about 5.0 degrees Celsius per second and without agitating the metallic melt to form a semi-solid material having a microstructure comprising rounded solid particles having a diameter no greater than about 50 μm dispersed in a liquid metal matrix. The Applicant submits that this combination of features is neither taught nor suggested by the '534 patent reference.

Notably, the '534 patent reference fails to teach or suggest the cooling of a metallic melt at a controlled rate falling within a range of about 0.01 degrees Celsius per second to about 5.0 degrees Celsius per second without agitating the metallic melt to form a semi-solid material having a microstructure comprising rounded solid particles having a diameter no greater than about 50 μm that are dispersed in a liquid metal matrix. To the contrary, the '534 patent reference discloses utilization of some form of agitation to produce a semi-solid material having a predetermined microstructure.

Specifically, the '534 patent specification discloses that "[i]t is possible to make the semi-molten metal spheric by flowing the molten metal. As a means to flow molten metal, for example, there is a means to stir the molten metal by electromagnetic force. Also, by flowing the molten metal while it is being filled into the die cavity, the structure changes from particle status into spherical status." (Col. 4, l. 66 – col. 5, l. 4; emphasis added). The Applicant submits that stirring and/or flowing the molten metal are both forms of agitation, and that either or both of these actions are required by the expressed teachings of the '534 patent reference.

Additionally, in Example 1 of the '534 patent reference it is disclosed that the molten metal is introduced into the casting sleeve 2 by pouring the molten metal "through the filter media 42 arranged at the pouring gate of ladle 41." (Col. 6, ll. 62-64). The Applicant submits that passage of molten metal through a filter media is also representative of a form of agitation. Moreover, the '534 patent reference discloses that "the temperature of the molten metal is lowered in the casting sleeve 2 . . . to form a spherical structure . . . . As for crystal grain at this moment, the average of circle equivalent diameter is 80 μm. Next, semi-molten metal 1B . . . is filled into a die cavity under pressure by use of a plunger 3 . . . . Granular structure becomes finer and changes into spherical structure at gate 6B during the process of filling and pressuring the molten metal. . . . [T]he average of circle equivalent diameter is 40 μm." (Col. 6, l. 65 – col. 7, l. 20; emphasis added). The Applicant submits that high-pressure injection of the molten metal also constitutes a form of agitation.

According to the expressed teachings of the '534 patent reference, some form of

agitation is used to produce a semi-solid material having a predetermined microstructure. In one embodiment, such agitation is provided via the shear forces developed by electromagnetic stirring of the molten metal. In another embodiment, such agitation is providing via the shear forces developed during high-pressure injection of the molten metal through the narrow gate 6B leading to the die cavity 36. Indeed, it is only by agitating the molten metal via stirring or flowing (i.e., high-pressure injection through a narrow gate) that particle diameters of less than 50 μm are realized. For at least the above-discussed reasons, independent claim 2, which recites that solid particles having a diameter no greater than about 50 μm are achieved without any form of agitation, is patentable over the teachings of the '534 patent reference. Accordingly, the Applicant respectfully requests withdrawal of the rejection of independent claim 2.

Dependent claims 3 and 4 depend from independent claim 2 and are patentable for at least the reasons supporting the patentability of base claim 2. Additionally, further reasons support the patentability of the claims depending from base claim 2. For example, claims 3 has been amended to recite that the controlled rate of cooling of the metallic melt falls within a range of about 0.01 degrees Celsius per second to about 0.5 degrees Celsius per second. As discussed above with regard to independent claim 1, the '534 patent reference fails to teach or suggest the recited cooling rate of the metallic melt.

Claim 10 has been rewritten in independent form and recites the steps of heating a metal alloy to form a metallic melt, transferring a portion of the metallic melt into a holding vessel, controllably adjusting the temperature of the metallic melt in the holding vessel to a

selected transfer temperature, regulating the transfer of an amount of the metallic melt from the holding vessel into a temperature-controlled forming vessel, and crystallizing the metallic melt in the forming vessel by cooling the metallic melt at a controlled rate to form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix.

Even assuming arguendo that the ladle 37 disclosed by the '534 patent reference could be considered a holding vessel, the temperature of the molten metal contained within the ladle 37 is clearly not controllably adjusted to a selected transfer temperature, as recited in independent claim 10. Instead, the temperature of the molten metal within the ladle 37 is subjected to uncontrolled ambient cooling. In no manner can it fairly be said that the ladle 37 satisfies the requirement of "controllably adjusting" the temperature of the molten metal to a selected transfer temperature. For at least the above-discussed reasons, the Applicant submits that the features recited in independent claim 10 are neither taught nor suggested by the '534 patent reference. Accordingly, the Applicant respectfully requests withdrawal of the rejection of independent claim 10.

Independent claim 50 has been amended in a manner similar to that of independent claim 1 and is patentable for reasons similar to those discussed above supporting the patentability of independent claim 1. Specifically, independent claim 50 has been amended to recite the steps of regulating the transfer of an amount of metallic melt into a temperature-controlled vessel, and crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate less than 0.5 degrees Celsius per second to produce a semi-solid material

having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix.

As discussed above, the '534 patent reference fails to teach or even suggest the step of cooling a metallic melt at a controlled rate less than 0.5 degrees Celsius per second. To the contrary, the '534 patent references discloses cooling rates that are higher than 0.5 degrees Celsius per second to produce a semi-solid material having a predetermined microstructure. Furthermore, as also discussed above, providing such a cooling rate would not have been an obvious design choice in view of the teachings of the '534 patent reference. Accordingly, the Applicant submits that the features of independent claim 50 are patentable over the '534 patent reference and respectfully requests withdrawal of the rejection of independent claim 50. Original dependent claims 51-57 and newly added dependent claims 77-84 depend either directly or indirectly from independent claim 50 and are patentable for at least the reasons supporting the patentability of base claim 50.

New independent claims 66 and claims 67-75 have been added and are believed to be in condition for allowance for at least the following reasons. Independent claim 66 is directed to a method of producing a semi-solid material without stirring and includes the steps of heating a metal alloy to form a metallic melt, preheating a vessel to a selected vessel temperature, and regulating the transfer of a select amount of the metallic melt into the vessel. The regulating comprises transferring the metallic melt into the vessel at a selected transfer temperature and at a selected transfer rate, and controlling a differential between the temperature of the metallic melt during the heating and the temperature of the metallic melt during the transferring. The method also comprises crystallizing the metallic melt in the

vessel by cooling the metallic melt at a controlled rate to form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix.

As discussed above, the '534 patent reference fails to teach or suggest the recited steps regarding regulation of the transfer of a select amount of metallic melt into a temperature-controlled vessel. For example, nowhere in the '534 patent reference is it disclosed or suggested that transferring of the molten metal into the casting sleeve 2 is accomplished at any particular transfer rate, nor is there an indication or suggestion regarding controlling a differential between the temperature of the molten metal during heating and the temperature of the molten metal prior to and during its transfer into the casting sleeve 2. Claims 67-75 depend either directly or indirectly from independent claim 66 and are patentable for at least the reasons supporting the patentability of base claim 66.

CONCLUSION

Attached hereto are three (3) pages that present a marked up version of the changes made to this application by the current amendment. The first page of the three (3) attached pages is captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE".

In view of the foregoing amendments and remarks, it is respectfully submitted that Applicant's application is now in condition for allowance with now pending claims 1-26, 50-57 and 66-84. Reconsideration of the present application, as amended, is respectfully requested. Timely action towards a Notice of Allowability is hereby solicited. The Examiner

is encouraged to contact the undersigned by telephone to resolve any outstanding matters concerning the present application.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Claims 1-3, 10, 20 and 50 have been amended as follows:

1. (Amended) A method of producing a semi-solid material without stirring, comprising:

heating a metal alloy to form a metallic melt;

[transferring an amount of the metallic melt into a vessel;]

[nucleating the metallic melt by] regulating the transfer of [the] an amount of the metallic melt into [the] a temperature-controlled vessel; and

crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate less than 0.5 degrees Celsius per second to form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix.

2. (Amended) [The method of claim 1, wherein the controlled rate of cooling of the metallic melt is] A method of producing a semi-solid material without stirring, comprising:

heating a metal alloy to form a metallic melt;

regulating the transfer of an amount of the metallic melt into a temperature-controlled vessel; and

crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate within a range of about 0.01 degrees Celsius per second to about 5.0 degrees Celsius per second and without agitating the metallic melt to form a semi-solid material having a microstructure comprising rounded solid particles having a diameter no greater than about 50 μm dispersed in a liquid metal matrix.

3. (Amended) The method of claim 2, wherein the controlled rate of cooling of the metallic melt is within a range of about 0.01 degrees Celsius per second to about [1.0] 0.5 degrees Celsius per second.

10. (Amended) [The method of claim 5, further comprising] A method of producing a semi-solid material without stirring, comprising:

heating a metal alloy to form a metallic melt;

[holding] transferring a portion of the metallic melt into [an intermediate] a holding vessel [prior to the transferring; and];

controllably adjusting the temperature of the metallic melt in the [intermediate] holding vessel to [the] a selected transfer temperature;

regulating the transfer of an amount of the metallic melt from the holding vessel into a temperature-controlled forming vessel; and

crystallizing the metallic melt in the forming vessel by cooling the metallic melt at a controlled rate to form a semi-solid material having a microstructure comprising rounded

solid particles dispersed in a liquid metal matrix.

20. (Amended) The method of claim [20] 1, wherein the rounded solid particles have a diameter in a range between about 40 μm and about 50 μm.

50. (Amended) A method of semi-solid forming a shaped article, comprising:

providing a metal alloy, a vessel and a mold;

heating the metal alloy to form a metallic melt;

[transferring an amount of the metallic melt into the vessel;]

[nucleating the metallic melt by] regulating the transfer[ring] of an amount of the metallic melt into [the] a temperature-controlled vessel; and

crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate less than 0.5 degrees Celsius per second to produce a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix;

feeding the semi-solid material from the vessel directly into the mold; and

forming the semi-solid material into a shaped article.

New claims 66-84 have been added.